

present a hazard to the downstream prefilter and HEPA filters. Firescreens, etc., shall be used to prevent roughing filters from impacting downstream prefilters or HEPA filters.

7.4 FILTER REPLACEMENT

The safe replacement of a contaminated glovebox filter must be planned in the design phase to facilitate proper execution. The filter change method and other maintenance functions, if other than site-specific, should be determined and planned. The designer should prepare a written preliminary filter change procedure along with the design documents. If the design is questionable due to an extreme custom nature, the glovebox should be mocked up so that an operational demonstration can be performed. It should be noted that special tools used to perform filter and maintenance operations in the past were employed out of necessity and should be avoided, if possible. In applications where controlled inert atmospheres are present, filter changes should be planned for times when other routine or special maintenance operations are taking place inside the box to reduce interruptions to operations and loss of inert gas, and to minimize the time required to reintroduce the inert gas into the box spaces.

The operational team directly involved in a filter change-out must wear appropriate respiratory protection, as specified by site-specific requirements. Filters installed inside the glovebox are accessible via the gloves on the glovebox. When the total activity of contaminants is high, additional protective measures may be necessary to reduce worker exposure. One of the safest and most common methods for preventing the spread of contamination while maintaining containment is bagging the filters in and out of the glovebox. The plastic bagging materials used are discussed in Section 6.2.3. When inert-atmosphere or oxygen-free environments are used inside the glovebox, additional provisions may be required to prevent air leakage into the box.

Replacement of a HEPA filter inside an air-ventilated box entails many steps that must be performed sequentially. The Standard Operating Procedures must be written and the team must be trained to perform the operations in a safe, controlled manner. Close coordination between maintenance and operating personnel is necessary

to establish a mutually satisfactory date and time for the filter change, to identify the boxes and systems involved, to procure the necessary materials, and to schedule personnel. The health and safety requirements of the industrial hygienist, health physicist, and safety engineer must be established. One of these specialists should be designated the health and safety supervisor and should be available to monitor the operation and assist as necessary.

When the necessary materials and tools are ready and all personnel have been instructed in their specific duties, final permission must be secured from the responsible operator to alter the airflow and replace the filters. The flow path of the exhaust system should be thoroughly understood, and persons responsible for the related exhaust systems that will be affected should be forewarned. For instance, if two glovebox exhaust systems manifold to the same blower, final filters, and stack, the removal of one system from service for a filter change will affect the system flow and pressure characteristics of the other system. Safety clothing and respiratory protection should be worn as directed by the health and safety supervisor. Typical steps required to change a filter and place a box back in service include the following:

1. Cease all glovebox operations and contain unsafe materials in suitable containers.
2. Cut off gas flow to the glovebox affected, and adjust flow through the remaining branches to restore a safe negative pressure and flow rate in each.
3. Bag a clean replacement filter (and prefilter if used) in a small, clear plastic bag with sufficient tape to hold the spent filter and prefilter with all of the hand tools required, as shown in steps A, B, and C of **FIGURE 7.11**. It is recommended that the hand tools needed for filter changing be introduced the first time the filters are changed, and then left in the glovebox for subsequent use if space and environment permit. Decontamination is often more costly than tool replacement.
4. Using the glovebox gloves, remove the dirty filter and prefilter from their mounting frame.
5. Insert the dirty filter and prefilter into an empty plastic bag along with any residual

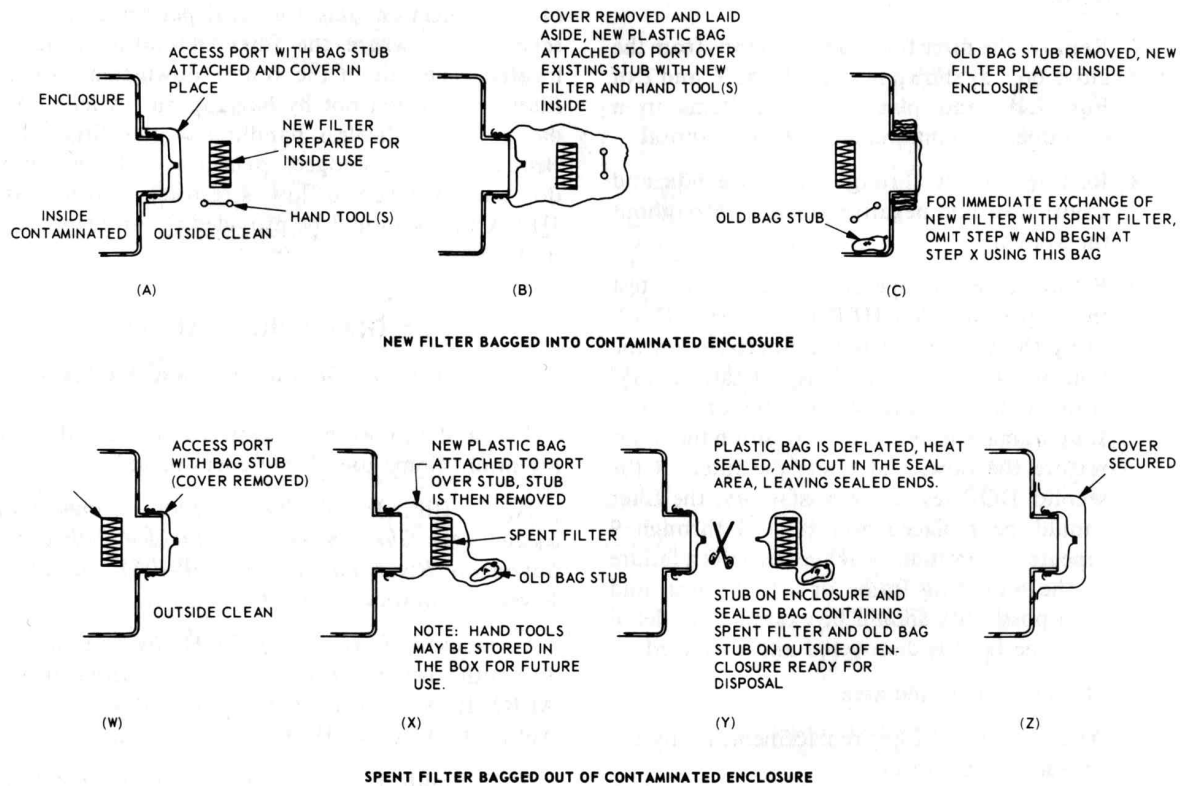


Figure 7.11 – Filter changing process.

- materials, slowly expel excess air, and seal with tape.
6. Inspect the gasket sealing face or fluid seal knife-edge of the mounting frame and clean if necessary. Place the replacement filter in position and secure the clamping devices. Place the new prefilter in position and secure.
7. Remove the dirty filters and all debris from the glovebox and place the removed items in a container for contaminated waste disposal.
8. Restore airflow through the glovebox and adjust the flow and negative pressure throughout the system.
9. Before glovebox operations are resumed, test the newly installed HEPA filter with Challenge agent, using the permanent test connections on the housing. If the test result is not satisfactory, stop the flow and inspect the filter for damage. If no damage is apparent, reposition the filter, restore the flow, and retest the filter. If the second filter challenge is unsatisfactory, the filter should be

replaced and steps 3 through 9 repeated. Continued leakage suggests a failure of the mounting frame, filter damage, or a faulty test, and each possibility should be examined in detail until the fault is discovered and corrected.

10. Decontaminate the area.

After successful filter replacement, notify the responsible operator.

Filters located outside a glovebox (used in some older glovebox installations) require convenient access for changing, and it is usually necessary to interrupt airflow during the change. Since they are located outside the glovebox, highly contaminated filters must be bagged during the change. Different bagging techniques provide different degrees of protection. The technique shown in **FIGURE 7.12** employs the principle of total containment when even minute leakage cannot be permitted. This method seals both ends of the air ducts, and no flow can occur downstream while the filter is removed. When uninterrupted airflow

through a box is required, this method of filter change necessitates the use of multiple exhaust connections on the box. An out-of-box filter in the process of being removed from a system by the procedure illustrated in FIGURE 7.12 (step 3) is shown in **FIGURE 7.13**. It should be noted that this type of installation should not be used on future nuclear installations due to the potential for contamination release and cleanup.

For other methods where bagging does not block the airflow path (e.g., using the housings represented by FIGURE 7.8), but merely encapsulates the filter being removed or replaced, there is a dependence on the damper in the duct to prevent blow-by (leakage) during a filter change. In other methods, isolation dampers or valves are used to isolate the filter during a filter change. The filter housing is still adjusted to the glovebox to remain slightly negative in pressure. The technique of bagging filters from housings (FIGURE 7.8) offers protection only for local personnel and the service area where the filter mounting device is located. The side of the system downstream of the filter is protected not by bagging, but by leak-proof dampers and flawless handling of the dirty filter. Because any dislodged particles will be swept downstream when airflow is restored, downstream HEPA filters should be provided to intercept these particles.

7.5 GLOVEBOX SAFETY

The history of glovebox safety in the United States came about with the use of very unsophisticated gloveboxes of simple design for simple operations. These were “sandblasting-gloveboxes with and without filters. Some early gloveboxes were actually manufactured from plywood. Glovebox use evolved from the need for safe working environments and reductions in operator exposure. This evolution led to more complex gloveboxes and more complex problems. Most lessons learned were the result of accidental experiences. Simply put, many variables existed due to lack of experience with glovebox use. Through all of these experiences, much was learned about ergonomics, operator safety, the importance of training, and fire and explosion protection. Ergonomic problems related to handling material, performing service functions, and transfers were discovered early and are still a critical requirement in glovebox design. Operator safety has improved as a result of better glovebox designs with less operator intervention. Training has become a critical path from design through commissioning, operation, and decommissioning. Fire prevention is important enough that DOE STD 1066-99, “Fire Protection Design Criteria,” Chapter 15,³⁰ was written for gloveboxes.